Operational Failures and Problem Solving: An Empirical Study of Incident Reporting

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An Empirical Study of Incident Reporting

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Operational failures occur in all industries with consequences that range from minor inconveniences to major catastrophes. Many organizations have implemented incident reporting systems to highlight actual and potential operational failures in order to encourage problem solving and prevent subsequent failures. Our study is among the first to develop and empirically test theory regarding which reported operational failures are likely to spur problem solving. We hypothesize that problem solving activities are especially likely to follow reported operational failures that provoke financial and legal liability risks. We also hypothesize that management commitment to problem solving, enacted through managers' communication and engagement practices, can encourage frontline workers to conduct problem solving. We test our hypotheses in the health care context, in which the use of incident reporting systems to highlight operational failures is widespread. Using data on nearly 7,500 reported incidents from a single hospital, we find support for our hypotheses. Our findings suggest that frontline workers' participation in problem solving is motivated by some inherent characteristics of the problems as well as by particular management practices.

1. Introduction

All industries experience operational failures. These can include "disruptions and errors in materials, information, and equipment" (Tucker 2007: 492) that stem from a variety of causes including inadequate equipment maintenance, inspection, and repair (Halstrick and Long 2009) as well as coordination problems among and between staff, management, and customers. The consequences of operational failures can range from minor inconveniences to major catastrophes. They can adversely affect product or service quality by distracting employees from value-adding activities, weakening process discipline, even causing direct harm to employees and customers (Tucker 2004). By eroding productivity and brand reputation, operational failures can also impair an organization's financial performance (Frei et al. 1999).

Voluntary incident reporting systems highlight actual and potential (e.g., "near miss") operational failures in order to stimulate problem solving. They can, and sometimes do, provide managers with

information unavailable elsewhere about opportunities to improve work systems (Hogan et al. 2008; Levtzion-Korach et al. 2008). Incident reporting systems are consistent with the belief that preventing and mitigating the conditions that lead to operational failures requires attention and problem solving rather than blaming individuals when errors occur (Senge 1990; Institute of Medicine 2001). Such systems can span multiple industries (Short and Toffel 2008), but more commonly focus on organizations within a particular industry such as aviation (Billings and Reynard 1984), nursing homes (Wagner et al. 2008), or hospitals (Farley et al. 2008). In principle, such systems are meant to help organizations learn from experience.

A growing literature that has examined the operational failures captured in incident reporting systems has focused extensively on the challenges of encouraging reporting (e.g., Lawton and Parker 2002; Leape 2002; Tucker and Edmondson 2003; Evans et al. 2006). Far less attention has been paid to questions of whether and how these systems serve their intended purpose of reducing operational failures and improving operational performance (Gandhi et al. 2005; Farley et al. 2008). A prominent hospital executive commented that "the Achilles heel of error reporting systems [is] the flawed notion that reporting has any intrinsic value, in and of itself," adding that "a growing number of incident reports is often taken as evidence that safety is improving [although] there is no persuasive evidence to support this association" (Wachter 2004: 538). To understand the effectiveness of incident reporting systems, it is important not only to stimulate more reports, but also to better understand how organizations respond to incidents already being reported, and why they might fail to do so.[1]

Our paper begins to address this concern by examining the circumstances under which frontline workers engage in problem solving following operational failures reported to the organization's incident reporting system. Staff involvement in the resolution of operational failures is desirable because staff often possess tacit knowledge required for problem solving (Hutter 2001). But there remains little

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[1] Examining why incidents are underreported and how incident data are used are not unrelated, as underreporting might be due to employee skepticism that the data will actually be used to implement operational improvements (Ramanujam et al. 2008).

understanding about how staff work to resolve operational failures reported in incident reporting systems (Macrae 2008).

We develop hypotheses that suggest that frontline workers are more likely to engage in problem solving when operational failures pose financial or liability risk. Responding to such operational failures might enable workers to mitigate or even avoid then in the future. We further argue that frontline workers are more likely to invest effort in problem solving when incidents occur in contexts in which managers demonstrate their commitment to problem solving. Prior research on management practices designed to involve workers in problem solving has examined practices employed by incident report analysts, but not by line managers (Macrae 2008). We examine two manifestations of managerial commitment: managerial communication campaigns that encourage problem solving, and managerial engagement that models desired problem solving behaviors. Finally, we suggest that these two forms of managerial commitment might substitute for or complement one another in the promotion of frontline problem solving.

We test our hypotheses in the context of the health care industry, a setting in which operational failures occur often, are widely reported, and engender consequences that can range from inconveniences that go unnoticed to death. Although patient safety has always been an important priority in health care, landmark studies that revealed serious safety problems in the United States (Kohn, Corrigan, and Donaldson 2000) and United Kingdom (Donaldson 2000) focused attention on the need for improvement.[2] We focus specifically on hospitals, a context in which many organizations have implemented incident reporting systems that collect data on operational failures (Farley et al. 2008). But there is little evidence of whether and, if they do, how these systems have been used to stimulate problem solving or improve quality (Benn et al. 2009). Our analysis of incidents reported within a large hospital in Massachusetts revealed that incidents that pose greater risk and incidents in which managers demonstrate

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[2] For example, an estimated 48,000 to 98,000 patient deaths annually in the United States are attributed to operational failures (Kohn et al. 2000). For context, this number exceeds the number of deaths due to motor vehicle accidents, breast cancer, or AIDS, is equivalent to the crash of one fully-loaded 747 every 1.5 days, and is many times the 6,000 workplace deaths that occur in the United States annually (Kohn et al. 2000: 2-3). Preventable medical errors resulting in injury are estimated to cost the health care industry $9-$15 billion per year, with another $9-$15 billion in costs associated with lost income, lost household production, and disability (Kohn et al. 2000: 3)

greater commitment to problem solving are more likely to result in problem solving among frontline workers.

Ours is the first quantitative study to examine problem solving initiated in response to operational failures identified by incident reporting systems. Our work complements recent qualitative studies that have explored how organizations use data from incident reporting systems to improve their operational practices (Farley et al. 2008, Ramanujam et al. 2008) and safety performance (Nuckols et al. 2007). We extend this research by developing theory that predicts the characteristics of incidents likely to promote operational improvement.

Our research has practical implications as well. We document when workers contribute to problem solving following incident reports and how particular management practices can promote greater frontline worker involvement. Our findings suggest that the potential for risk mitigation is an important predictor of which incident reports will elicit problem solving. Beyond this, through their communication and engagement, line managers can stimulate increased problem solving among workers. Further, absent managers' regular engagement in problem solving, communication about its importance can promote more problem solving among workers. These findings can be used by organizations to increase the contribution of incident reporting systems to operational performance improvement.

2. Theory and Hypotheses

Organizations employ a variety of strategies and tools to improve process quality including ISO 9001 (Corbett, Montes-Sancho, Kirsch 2005; Levine and Toffel 2009), Six Sigma (Choo, Linderman, Schroeder 2007), Total Quality Management (Hendricks and Singhal 1997; Sterman, Repenning, and Kofman 1997; Easton and Jarrell 1998) and high reliability techniques (Leveson et al. 2009). Essential to the success of each of these approaches is developing opportunities for frontline workers to engage in problem solving both in anticipating and responding to problems. Prior research that examines how problem solving can improve process quality can be grouped into four broad categories. First, several studies have shown that policies and procedures that emphasize quality and safety can forestall the

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occurrence of problems (e.g., Roberts 1990; Roberts, Rousseau, and LaPorte 1994; Weick and Sutcliffe 2001). A second stream of literature examines how organizations developed abilities related to mitigating the immediate consequences of problems that arise, which makes them particularly resilient (e.g., Weick and Sutcliffe 2001). A third body of research has revealed problem solving techniques such as root-cause analysis to resolve the underlying causes of problems and thereby prevent their recurrence (e.g., MacDuffie 1997; Carroll 1998). Finally, organizations can use information about problems and problem solving in a feedback loop to enhance policies and procedures that improve quality performance more broadly (e.g., Garvin 1993). For example, documenting and categorizing problems and their solutions are necessary steps to learning from operational failures and improving process quality (Tax and Brown 1998).

Largely missing from these literatures is a comprehensive understanding of when such problem solving takes place and how to promote it. In one of the few studies that addresses this issue, MacDuffie (1997) observed frontline workers in three automobile assembly plants to use heuristics to prioritize which operational failures to address. In these plants, frontline workers avoided attempts to solve problems that would (1) not be of concern to customers, (2) require bureaucratic intra-organizational coordination, and (3) impose an ongoing cost increase. In contrast, observers of the Toyota Production System have found frontline problem solving to occur immediately in response to each operational failure that is discovered (Spear and Bowen 1999).[3] We know far less about when problem solving occurs in organizations that fail to achieve this high standard. Like Tucker and Edmondson (2003), our study begins to address this gap by exploring when frontline workers problem solve in response to operational failures. We further explore how managers can encourage this. Frontline workers can drive process quality improvement by engaging in problem solving in response to the operational failures they encounter (National Research Council 1996). Specifically, worker participation in problem solving has

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[3] For example, in the Toyota Production System: "A worker encountering a problem is expected to ask for assistance at once. The designated assistant is then expected to respond immediately and resolve the problem within the worker's cycle time" (Spear and Bowen 1999: 101).

been identified as an essential component of effective risk mitigation and learning from past incidents (Macrae 2008).

We hypothesize that the propensity for frontline workers to problem solve in response to incidents depends on particular characteristics of an incident as well as on the context created by managers when incidents occur. We argue that more problem solving will occur when operational failures present financial and legal liability risks. Workers will seek to mitigate these risks by engaging in more problem solving. We further argue that workers will engage in more problem solving when managers emphasize, by exhibiting commitment to problem solving, that problem solving behavior is appropriate and desirable. Managers can demonstrate such commitment by (1) communicating the importance of problem solving, and (2) actively engaging in problem solving behavior themselves. Finally, we maintain that there is an interaction between managerial communication and managerial engagement; they might be substitutes, with managerial communication having a stronger effect when managerial engagement is low, or complements, with communication being particularly effective when engagement is high. We address these, in turn, below.

2.1. Risk Mitigation and Problem Solving

We hypothesize that problem solving is more likely to accompany operational failures that pose risk to an organization or its employees or customers. We consider two sources of risk that are particularly threatening to organizations: financial risk and legal liability risk.

2.1.1. Financial risk. Because they can reduce operating capacity and even halt work altogether, operational failures risk financial costs. Failures that occur within organizations' most profitable units risk the greatest financial losses. Organizations mitigate the consequences of such failures by investing in more innovative services and higher service levels for their most profitable customers (Christensen 1997; Campbell and Frei 2004). Preventing and quickly resolving operational failures that affect their most profitable services also helps organizations maintain brand reputation, which protects profitability (Frei et al. 1999). For these reasons, we argue that frontline workers in organizations' more profitable areas are

especially likely to be provided with resources such as managerial attention, slack time, training in problem solving, and budget. Problem solving following incidents is thus especially likely to occur in more profitable areas.

HYPOTHESIS 1. *Incidents that pose risk to particularly profitable services will generate more problem solving by frontline workers.*

2.1.2. Legal Liability Risk. Incidents that pose the risk of legal liability threaten the financial performance and reputation of the organization as well as of the individuals involved. Individuals and organizations are thus particularly likely to respond to failures that occasion legal exposure. Professional and regulatory organizations increasingly support disclosing mistakes, offering apologies, and remedying underlying problems to prevent or minimize potential litigation as well as for ethical reasons (Woods 2004; Leape 2007). Taking action to solve problems when incidents occur creates the potential to decrease the risk or consequences of litigation. Such responses can also provide a substantive message that the organization can relay to the media to defend its reputation and legitimacy with employees and customers. Self-imposed regulation to mitigate risks can also reduce pressure for greater government regulation or oversight (Enthoven and Singer 1995). For all these reasons, incidents that provoke the risk of litigation are particularly likely to generate problem solving.

HYPOTHESIS 2. *Incidents that pose more risk of legal liability will generate more problem solving by frontline workers.*

2.2. Management Commitment and Problem Solving

Worker dedication to problem solving can be influenced not only by the risk inherent to incidents, but also by the context created by management. Management commitment, exhibited through communication and level of engagement (Zbaracki 1998), can influence worker behavior (Naveh, Katz-Navon, and Stern 2005). Schein (1992) proposed that leadership is the key mechanism by which culture is embedded in organizations. Frontline workers look to managers to signal organizational values, expectations, and priorities (Schneider et al. 2005). Managers can inculcate quality enhancing behaviors

in frontline workers through what they say and do. In this section, we hypothesize that managers who demonstrate commitment to problem solving can encourage problem solving responses to operational failures among frontline workers. Specifically, we examine awareness campaigns as a communication strategy and managerial behavior as an engagement strategy.

2.2.1. Managerial Communication Strategies. In many organizations, managers sponsor short-term awareness campaigns that target areas such as safe work practices or employee health. Such campaigns seek to command employees' attention and encourage behavior that improves organizational performance (Zohar 2002a; Naveh et al. 2005). Persuasive managerial communications, especially those that "arouse enthusiasm by appealing to a target's values, ideals, and aspirations," are one mechanism by which managers foster employees' adoption of desired behaviors (Falbe and Yukl 1992: 640). Managers can emphasize to frontline workers a particular organizational priority by the number of times they mention it, amount of time they spend discussing it, and passion with which they convey their message (Zohar 2002b). In response, frontline workers are more likely to engage in behaviors that support the campaign's goals. In our context, this yields the prediction that an awareness campaign focused on operational performance improvement will result in more problem solving in response to incidents.

HYPOTHESIS 3. *Incidents that occur during or soon after a related managerial communication campaign will generate more problem solving by frontline workers.*

2.2.2. Managerial Engagement Strategies. Managers can use action as well as communication to attempt to influence employee behavior. They can, for example, model behaviors they want subordinates to emulate. Leading by example has proven particularly effective in encouraging employees to engage in discretionary behaviors (Yukl and Lepsinger 2005; Potters, Sefton, and Vesterlund 2007). For example, when managers take action to help resolve procedural violations, employees are more willing to report such violations to managers (Offermann and Malamut 2002). In the same way, we expect that managers signal the importance and appropriateness of problem solving by engaging in such discretionary behavior. We consequently expect more problem solving among frontline workers in organizational units in which managers are more engaged in problem solving.

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HYPOTHESIS 4. *Incidents that occur in units with higher managerial engagement in problem solving will generate more problem solving by frontline workers.*

2.2.3. Managerial Communication and Engagement: Moderating Effects. Managers' ability to promote problem solving among workers might depend not simply on the amount of commitment and engagement they demonstrate, but also on the combination of strategies they employ. Strategies for engaging frontline workers in problem solving might, for example, substitute for one another (Jauch, Osborn, and Terpening 1980). Workers who regularly observe high levels of engagement on the part of their managers might be unaffected by additional communications about the importance of problem solving. But such communication campaigns might be essential to generating problem solving behavior on the part of employees who work in environments that lack regular managerial engagement. Such campaigns might enable frontline workers to overcome the inertia of low managerial engagement, resulting in a situation akin to a "punctuated equilibrium" (Gersick 1988) that creates a short-term burst of problem solving activity. Just as organizations sometimes adopt innovative technologies to improve operations in fairly rapid episodes, so too can short-term awareness campaigns trigger "windows of opportunity for adaptation and experimentation" (Tyre and Orlikowski 1994: 99) with problem solving. These arguments lead us to hypothesize that management communication campaigns will be especially effective in generating more problem solving in units with lower managerial engagement. In other words, these two managerial tactics might serve as substitute approaches to encouraging frontline workers to engage in problem solving.

HYPOTHESIS 5a. *Management communication campaigns weaken the influence of managerial engagement in generating more problem solving by frontline workers.*

It is also possible that frontline workers accustomed to managerial engagement in problem solving might be especially likely to respond to other forms of managerial commitment such as awareness campaigns. The success of awareness campaigns might rely on employees believing management communication tactics to be not merely symbolic activities, but rather to emphasize core organizational values. Managerial consistency in action and communication is associated with frontline workers'

commitment and willingness to cooperate (Kopelman, Brief, and Guzzo 1990; Rogg et al. 2001). Such consistency might be particularly helpful when employees are called upon to expend extra effort towards a particular goal. Frontline workers who witness low levels of managerial engagement in the domain being promoted, on the other hand, might be inclined to view awareness campaigns more cynically. These arguments suggest that managerial communication and managerial engagement are complements, with greater levels of managerial engagement enhancing the responsiveness of frontline workers to managerial communication campaigns.

> HYPOTHESIS 5b. *Management communication campaigns enhance the influence of managerial engagement in generating more problem solving by frontline workers.*

3. Empirical Setting and Data

We test our hypotheses using data obtained from the electronic incident reporting system of a large hospital. Few prior studies have investigated the content of incident reporting data because access is restricted to protect the confidentiality of patients and health care providers. We nevertheless chose to conduct our study in a health care setting because operational failures are frequent and can occasion significant health and financial consequences (Kohn et al. 2000). In the empirical context of hospitals, we use the term "operational failures" to refer to any safety-related work system risk, concern, or failure noted by workers during the performance of their jobs (Tucker et al. 2008). Often referred to in the health care context as "incidents" or "errors," these can include mistakes, inadvertent occurrences, and unintended events that might or might not result in patient injury (Liang 2004). Whereas some incidents result in harm, many do not as a result of caregiver vigilance or robust patient physiology (Reason 2000). Incidents that could have harmed a patient but were prevented from doing so through planned or unplanned recovery are referred to as near misses (Kaplan and Rabin Fastman 2003). In our setting, employees are encouraged to report all types of incidents including those that resulted from inadvertent, unintended, or inappropriate intended actions regardless of whether they were prevented midcourse or resulted in patient harm.

The hospital's incident reporting system, a customized commercial database, was implemented in June 2004. A dedicated patient safety team of four full time equivalent employees was employed by the hospital to manage the incident reporting system and facilitate incident follow-up (among other responsibilities). Reporting was voluntary and confidential (but not anonymous). Reports could be filed by any hospital employee on computers located throughout the hospital. Reporters responded to a set of structured, semi-structured, and free-text questions designed to gather basic information about an incident (e.g., type, date, and time), who was involved (e.g., names of patient, staff, and doctors), the outcome (e.g., the degree of patient harm that resulted), contributing factors, and actions taken in response. Filed reports were automatically routed to a designated unit manager, process manager, risk manager, and patient safety manager.[4] Although any of these managers could enter additional information about the reported incident, unit managers were primarily responsible for follow-up. Managers completed a set of fields pertaining to follow-up and resolution accessible only to them. They were also able to send notes with attachments to specific recipients and enter structured and free-text data explaining how the incident had been addressed.

We examined incidents reported by all hospital units between January 1, 2005 and May 31, 2008.[5] Our dependent variables, intended to capture problem solving in response to incidents, were derived from the actions taken following an incident as recorded by the incident reporter and occasionally updated by a manager. To document the problem solving activities undertaken in response to the incident, the system provided a structured list of both "tick-box" options and a field in which free-text actions could be added. The incident reporting system also provided a free-text field in which to describe incidents. A detailed preliminary review of several incidents revealed that reporters had documented

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[4] The risk management department and patient safety manager received all incident reports. Unit managers received reports specific to their units. Process managers received reports related to specific incident types, regardless of unit. Nursing managers received reports in which permanent harm or death resulted. Finally, medical and administrative directors received reports specific to the service line to which a patient had been admitted. Reports pertaining to incidents that involved multiple units were disseminated accordingly.

[5] We exclude incidents reported during months immediately following the hospital's installation of the system (June-December 2004) to avoid potentially inaccurate or incomplete data entered by staff members who might have been unfamiliar with the system. The sample extends through the most recent date of incidents and associated follow-up actions that we were able to obtain.

follow-up actions to some incidents in the text field rather than in the structured list. To avoid confounding our results with such reports where follow-up actions were underrepresented in the structured list, we examined the prevalence of this problem and identified four incident types in which reporting actions only in the free-text field was rare: ID/Documentation/Consent, Blood/Blood Product, Lab Specimen/Test, and Surgery/Procedure.[6] Table 1 reports the proportion of our sample represented by each of these incident types. Our dataset includes 9,758 reported incidents during the study years for these four incident types. However, our empirical models (described below) employ a key independent variable that lags one year, effectively restricting our analysis to the 7,407 incidents reported January 1, 2006 through May 31, 2008.

To assess the generalizability of our setting, we compared our hospital to all hospitals in Massachusetts based on a 2008 assessment of serious reportable events (SRE) legally required to be reported to the state regulator (Massachusetts Department of Public Health 2009). Our hospital was within one standard deviation (1.37) of the mean hospital rate of 1.06 SREs per 10,000 patient days. Comparing the three most common types of SREs to the average hospital in Massachusetts, our hospital had a slightly lower proportion of environmental events, a higher proportion of care management events, and a similar proportion of surgical events. This offers some indication that our setting includes a range of operational failures similar to those in other Massachusetts' hospitals.

3.1. Dependent Variables

To examine the occurrence of problem solving in response to incident reports, we created two variables based on actions taken by staff, as recorded in the structured list within the incident report. We

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[6] Budget and time constraints prevented us from individually reviewing this text field for the many thousands of incident reports. Instead, we focused on incident reports that had no actions reported in the action field, took a stratified random sample of 20 of each incident type, and counted the number of reports in which actions were documented in the free-text description field. Based on the results of this investigation, we focused our analysis on the four types of incidents in which underreporting of actions occurred least often (in fewer than 20% of the incident reports for each type in our sample). Although our primary analyses rely on these four incident types with the least measurement error, we report the results of a set of robustness tests that analyze a broader set of 11,930 incidents across thirteen types. In addition to our focal four, these include Airway Management, Coordination of Care, Diagnosis/Treatment, Diagnostic Test, Environment, Fall, Identification/Documentation/Consent, Line/Tube (related to intravenous therapy), Maternal/Childbirth, and Skin/Tissue.

created *any staff-reported problem solving* as a dichotomous variable coded "1" for incidents in which at least one problem solving action was taken in response to a reported incident, and "0" otherwise. We also calculated the *number of staff-reported problem solving actions taken* to identify which incidents resulted in more actions.

3.2. Explanatory Variables

3.2.1. Financial Risk. More profitable services impose greater financial risk because incidents have the potential to incur greater financial losses. The profitability of hospital services varies substantially (Dobson et al., 2005). General hospitals rely on more profitable services to subsidize less profitable ones. Horwitz (2005) categorized specific hospital services as "relatively profitable" (e.g., orthopedic surgery) or "relatively unprofitable" (e.g., inpatient psychiatric). In consultation with our hospital contact, we mapped this list of profitable and unprofitable services to the locations in the hospital in which incidents occurred. We created a dichotomous variable, *profitable service*, coded "1" for incidents that took place in areas controlled by a relatively profitable service, and "0" for all other incidents. To distinguish within the latter category services Horwitz classified as unprofitable from services at our focal hospital not included in the Horwitz taxonomy (and units that provided a mix of profitable and unprofitable services), we created a second dichotomous variable, *profitability unknown*, coded "1" for the latter two situations, and "0" for incidents associated with unprofitable services.

3.2.2. Legal Liability Risk. We created two measures to capture various dimensions of legal liability, as reflected in the risk of malpractice lawsuits, the primary channel through which legal liability is manifested in the health care industry (Kessler and McClellan 1996). Liability is heightened for an incident that involves a patient because the risk of patient harm is more likely to lead the patient to perceive that that mistakes might have been made in the course of her or his treatment, which increases the risk of the patient filing a lawsuit. We determined that a patient was involved in an incident if the incident reporter populated the "patient age" field, noted in the "severity" field that patient harm had

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occurred, classified the incident type as a fall, or reported a patient to be in pain. We coded *patient*

involved "1" if any of these indicators implied that the incident involved a patient, and "0" otherwise.

Our second measure, reflecting more extreme cases of liability risk, relies on physicians' medical

malpractice premium rates, which are based on the average risk of loss from lawsuits filed against doctors

in each specialty. Rodwin et al. (2008) found that the highest malpractice premium rates in Massachusetts

were incurred by physicians who specialized in orthopedic spinal surgery, major neurological surgery,

and obstetrics and obstetrics/gynecology. In 2005, physicians in these specialties paid an average of

$95,045 for malpractice insurance, compared to $17,810 paid by the average physician for the same dollar

coverage. Although our incident report data did not contain sufficient detail for us to identify which, if

any, incidents involved orthopedic spinal surgery or major neurological surgery, we were able to identify

incidents associated with obstetrics and obstetrics/gynecology (hereafter obstetrics for simplicity).[7] We

created *obstetrics* as a dichotomous variable coded "1" for incidents that had the potential to result in an

obstetrics malpractice claim including incidents that occurred in the obstetrics ward, nursery, or neonatal

intensive care unit (NICU), incidents for which the patient was admitted for newborn, newborn specialty,

or obstetrics care, incidents involving a patient less than one month old, and incidents classified as

maternal/childbirth, and "0" otherwise.

3.2.3. Managerial Communication. The hospital runs in early March an annual campaign

designed to generate hospital-wide awareness of patient safety. During this week long campaign, the

hospital promotes patient safety practices via the hospital bulletin, a table provided with patient safety

materials, and a patient safety knowledge contest (e.g., crossword puzzle or quiz). The hospital promotes

increased incident reporting by giving staff credit in the hospital cafeteria for each report filed during the

campaign week. Patient safety team members at the hospital report that this campaign often results in

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[7] Our focus on obstetrics is supported by prior research that has shown heightened sensitivity for pregnant mothers and newborns to place doctors in obstetrics and gynecology at substantially higher risk of malpractice lawsuits than doctors in most other specialties (Studdert et al. 2006; Kim 2007). Malpractice lawsuits involving child victims can elicit particularly large damage awards that reflect higher future earnings losses and a greater sense of moral outrage regarding the innocence of such victims. For example, Finley (2004) found that women and children receive higher noneconomic loss damage awards. Even when no harm occurs, risk posed to such patients can attract negative media attention.

heightened awareness and increased reporting throughout the months of March and April. Increased problem solving is also expected as a result of the attention to safety. We consequently created a dichotomous variable, *awareness campaign*, coded "1" for incidents that occurred in March or April, and "0" otherwise.

3.2.4. Managerial Engagement. At our hospital, the unit manager is the primary individual tasked with responding at a managerial level to incident reports filed by frontline workers. As explained above, unit managers automatically receive a copy of each incident report filed in their unit. The associated set of manager fields in these reports includes a structured field in which unit managers can record the actions taken as a result of their involvement. Examples include "communication process enhanced" and "leadership/responsibility defined." We used this field to create a variable that captures the overall level of manager problem solving within each unit. *Managerial engagement* is the proportion of total incidents reported in each unit in each calendar year for which a manager reported at least one action. For units that had no reported incidents in a calendar year, we recoded *managerial engagement* from missing to zero and created a dichotomous variable coded "1" to denote such instances, and "0" otherwise. In the models, we lag this variable one year to capture the prevailing level of managerial engagement within units in which incidents were reported.

3.3. Control Variables

We created a set of control variables to capture additional factors that might influence problem solving in response to incidents.

3.3.1. Alignment with Organizational Mission. Many service organizations owe their success to a deliberate focus on achieving excellence for the subset of service attributes most valued by their customers (Frei 2008). Such service attributes and capabilities reflect not only an organization's technical skills but also its deeply rooted values (Leonard-Barton 1992), and become central to the organization's core mission. Operational failures that put an organization's mission at risk because they involve key services or capabilities might be more likely to elicit a response from management and employees. We

developed a set of measures to capture various dimensions of the hospital's primary mission of providing high-quality, patient-centered care. Incidents that take place in patient or clinical areas, because these are the locations in which care is delivered, are likely more aligned with the hospital's primary mission. We created *patient or clinical area* as a dichotomous variable coded "1" for incidents that occurred in a unit, patient room, or treatment area, and "0" for incidents that occurred elsewhere (e.g., in a public area such as hallway or cafeteria). We also created a dichotomous variable to denote instances in which the area was not specified in the incident report.

The core technical skill and value of hospitals is patient care. According to the Hippocratic Oath, chief among patient care aims is "first, do no harm." Incidents that result in patient harm thus pose a greater conflict with a hospital's primary mission than incidents that result in no or only minor harm. A field in the incident reporting system explicitly indicates whether a patient experienced pain as a result of the reported incident. Based on this data, we created four dichotomous variables to capture varying levels of patient harm: *low severity* incidents referred to near misses and incidents that did not result in patient harm; *temporary patient harm* referred to incidents that resulted in temporary patient harm; *permanent patient harm* referred to incidents that resulted in permanent patient harm; and *patient death* referred to incidents that resulted in death.

3.3.2. Equipment. Incidents involving equipment might spur a unique type of action related to repairing or replacing devices. We created a dichotomous variable called *equipment* coded "1" when equipment was involved in a reported incident, and "0" otherwise.

3.3.3. Incident Type. The incident reporting system used in this hospital requires that incidents be classified as one of several types (a mutually exclusive categorization determined by the reporter). The qualitative nature of problem solving differs by incident type. For example, the types of actions taken after an identification/documentation/consent incident (e.g., documentation amended, ID clarified) are distinct from the types of actions taken after a blood-related incident (e.g., notify blood bank, transfusion stopped). We developed a set of incident type dummies to account for such unobservable differences in responses to different incident types.

3.3.4. Month. Discussions with our hospital contacts revealed that problem solving appeared to vary across months of the year. For example, they perceived lower levels of problem solving during holiday months in the summer and winter when many employees take vacation time. To address such concerns, we developed a full set of month dummies.

3.3.5. Year. Responses to incidents might also be affected by changes in annual budgets and strategic priorities, whether the hospital was subjected to a bi-annual visit by the Joint Commission to reevaluate its accreditation status, and other differences between years. We developed a full set of year dummies to account for such factors.

4. Empirical Approach and Results

Summary statistics and correlations for our variables are reported in Tables 2 and 3. These show that 24.1% of incidents resulted in at least one staff-reported problem solving action. On average, there were 0.33 staff-reported actions per incident. Below, we test our hypothesized relationships between incident characteristics, managerial context, and staff-reported problem solving. We then describe several robustness checks and an extension whereby we explore the determinants of problem solving undertaken and reported by managers rather than frontline workers.

4.1 Hypothesis Testing

To assess how our hypothesized variables affect the likelihood that problem solving occurred in response to an incident, we estimated a logistic regression model that predicts our dichotomous dependent variable, *any staff-reported problem solving*. Results are presented in Table 4 as odds ratios (OR) with robust standard errors (Column 1a).

We also examined the extent to which our key independent variables affected the *number of problem solving actions taken* in response to each incident. Because the dependent variable exhibited overdispersion (mean=0.33, variance=0.59), we estimated this count model using negative binomial regression. These results are presented in Table 4 as incidence-rate ratios (IRRs) with robust standard errors (Column 2a).

4.1.1. Financial Risk. We found no evidence that incidents that involved more profitable services were more likely to motivate problem solving, as predicted in Hypothesis 1. Instead, we found the opposite, that problem solving took place less often within such service areas (OR=0.71; p<0.05). Evaluated with all other variables set at their means, our model predicts that incidents that involve a more profitable service had a 5.4% probability of resulting in staff-reported problem solving, compared to a 7.4% probability for incidents that involved other services. When problem solving did take place, incidents involving more profitable services were associated with less problem solving (IRR=0.86; p<0.10), not more as we had predicted. The magnitude of this difference is small, however. With all other variables set at their means, incidents involving a more profitable service were associated with 0.13 actions on average, compared to 0.15 actions for incidents that involved other services. Together, these results indicate that incidents that evoke greater financial risk are no more likely (are in fact *less* likely) to spur problem solving than other types of incidents, and when such incidents are addressed, problem solving is no more comprehensive. We return to this counterintuitive finding in the discussion.

4.1.2. Legal Liability Risk. Problem solving was more likely to follow incidents that posed potential legal liability, as predicted by Hypothesis 2. The probability of any staff-reported problem solving was higher when patients were involved (OR=3.5; p<0.01) and when incidents involved obstetrics (OR=1.5; p<0.01). Evaluated with all other variables at their means, our model predicts that incidents involving patients had an 8.1% probability of spurring problem solving, a substantial increase over the 2.4% probability for incidents not involving patients. Our model also predicts that for incidents that evoked heightened liability risk by involving obstetrics, the probability of any problem solving was 9.7%, compared to a 6.9% probability for incidents that did not involve obstetrics. This corresponds to a 41% increase in the probability of problem solving.

Incidents that involved patients and obstetrics tended to prompt more problem solving actions (Patient Involved: IRR=1.9; p<0.01 and Obstetrics: IRR=1.4; p<0.01). With all other variables set at their means, incidents that involved patients averaged 0.16 actions, compared to 0.08 for incidents that did not

involve patients, and incidents that involved obstetrics 0.20 actions, compared to 0.15 for incidents that did not involve obstetrics.

4.1.3. Managerial Communication. Incidents reported during and shortly after an awareness campaign were significantly more likely to result in at least some staff-reported problem solving compared to incidents reported in other periods (OR=1.5; $p<0.05$). Our model predicted that incidents that occurred during campaign periods had a 9.7% probability of triggering problem solving activities, compared to a 6.5% probability for incidents reported outside campaign periods, when evaluated with all other variables at their means. This 3.2 percentage point difference corresponds to a 49% increase in the probability of problem solving associated with campaigns. We found no evidence that incidents reported during or closely following an awareness campaign affected the number of problem solving actions taken, however.

4.1.4. Managerial Engagement. We also found evidence that managerial action was associated with more staff problem solving. Incidents reported in units in which managers were more actively engaged in problem solving were significantly more likely to spur staff-reported problem solving (OR=1.8; $p<0.01$). Compared to incidents reported in units with no managerial engagement, incidents reported in units with 100% managerial engagement (i.e., managers responded to all reported incidents in the prior year) were associated with a 5.1 percentage point increase (from 6.4% to 10.7%) in the likelihood of staff-reported problem solving. This represents a 68% relative increase. When problem solving did take place, incidents in units with high managerial engagement were associated with more problem solving activities (IRR=1.6; $p<0.01$). With all other variables set at their means, incidents reported in units with no managerial engagement averaged 0.14 actions, compared to 0.21 actions in units with 100% managerial engagement.

4.1.5. Interaction of Managerial Communication and Engagement. To test whether awareness campaigns had differential affects on the propensity for problem solving across units with differing levels of managerial engagement, we parsed *managerial engagement* into two variables: *managerial engagement during awareness campaigns*, and *managerial engagement not during awareness campaigns*.

Each of these variables took the value of managerial engagement during the time period specified, and was coded "0" throughout the rest of the year. We substituted these two variables for the single managerial engagement variable and report the results of these logistic and negative binomial regression models in Columns 1b and 2b of Table 4. Throughout most the year, when there was no awareness campaign, incidents reported in units with greater levels of managerial engagement were more likely to be accompanied by at least some staff problem solving (OR=2.02; p<0.01 from Column 1b), and more problem solving activities (IRR=1.75; p<0.01 from Column 2b). In contrast, we found no evidence that managerial engagement affected either the likelihood of staff-reported problem solving (OR=1.07; p=0.86 from Column 1b) or the number of problem solving activities (IRR=1.00; p=0. 98 from Column 2b) during awareness campaigns.[8] This suggests that campaigns have a greater impact on increasing staff-reported problem solving in units with low managerial problem solving, a substitution effect predicted by Hypothesis 5a. This is illustrated in Figure 1, which depicts the predicted probability of staff-reported problem solving at different levels of managerial engagement when awareness campaigns were and were not taking place. In units with no managerial engagement, the predicted probability of staff-reported problem solving increased three-fold from 4.9% outside of campaign periods to 15.2% during campaigns. In units with 100% managerial engagement, the predicted probability of staff-reported problem solving increased from 9.5% outside of campaign periods to 16.1% during campaigns. Campaigns thus had a much stronger influence on units with lower managerial engagement. We did not find support for the complementary relationship between managerial communication and managerial engagement predicted in Hypothesis 5b.

4.2. Robustness Tests

4.2.1 Scope of Staff-reported Problem Solving.
A potential concern with our analysis is that our dependent variables do not distinguish between types of problem solving actions. Whereas some problem

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[8] Wald tests confirmed that the coefficient on *Managerial Engagement during awareness campaign* and *Managerial Engagement not during awareness campaign* significantly differed from each other in the logit model (Model 2 reported in Table 4: χ^2= 2.84; p<0.10) and negative binomial model (Model 4 reported in Table 4: χ^2= 4.89; p<0.05).

solving actions address only specific operational failures, others attempt to prevent the occurrence of similar incidents. To determine whether the relationships observed in our main analysis were robust to this distinction, we categorized each problem solving action as either "narrow problem solving" or possessing the "potential for broad problem solving." "Narrow" actions attempt to restore the situation (including patients, frontline workers, equipment, and the environment) to the pre-incident state, or prevent the *identical* incident from occurring, or both, and might prevent similar incidents from occurring through notification of specific frontline workers such as attending physicians about an incident. "Potential for broad" actions include those more likely to prevent future incidents. These consist of actions that involved notifying individuals capable of addressing a failure's cause, including senior administrators and frontline workers in other departments, about an incident, repairing a piece of equipment, or changing a policy.

We created a categorical variable with three levels of ***scope of staff-reported problem solving***, "no problem solving" for incidents with which no problem solving actions were associated (76% of incidents), "narrow problem solving" for incidents with which only narrow actions were associated (2%), and "potential for broad problem solving" for incidents with which at least one associated action had the potential for broader problem solving (22%). We then estimated a multinomial logistic regression model with *scope of staff-reported problem solving* as the dependent variable, predicted by the same set of independent and control variables included in our main model. The results (not shown to conserve space) indicate that all of our independent variables were just as likely to prompt narrow problem solving as to prompt problem solving with the potential for a broad response.[9]

4.2.2 Additional Incident Types. Although our main analysis focused on the four incident types for which underreporting of actions was rare in order to minimize measurement error, we also estimated our logistic and negative binomial models using data for all incident types to determine whether relationships revealed in our main results are observed in the broader sample of 11,930 incidents across

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[9] Specifically, we used Wald tests to assess the equality of the multinomial logistic regression coefficients across the "deep" and "shallow" categories. We found no statistically significant difference between the likelihood of shallow versus deep problem solving for all of our independent variables.

thirteen incident types.[10] Despite the noise introduced by underreporting of actions, these results (not shown to conserve space) are largely consistent with our main results. We emphasize that these results are unbiased only under the key assumption that the underreporting of actions more prevalent in this broader sample is uncorrelated with the error term in each of the models (i.e., with the relationships between the independent variables and the propensity to engage in problem solving). In our logit model predicting *any staff-reported problem solving*, odds ratios were of similar magnitude as our main results, except that the odds ratio on awareness campaign was now much lower and no longer statistically significant (OR=1.05; p=0.68). This could be due to the higher volume of incident reports filed during campaigns (described below), which exacerbated the underreporting of actions in the broader array of incident types (i.e., frontline workers might be more likely to underreport actions when they are filling out more reports per day and presumably spending less time on each). Comparing the results with those of our count model predicting *number of staff-reported problem solving actions* revealed a similar pattern. Incidence-rate ratios were of the same magnitude and significance, except that the IRR on campaign, which was not significant in our main results, was now significant, with fewer problem solving actions taken during campaign periods (IRR=0.83; p<0.05). We favor the same interpretation, that underreporting of actions in the incident reporting system was likely exacerbated during campaigns, making the number of actions taken in response to incidents during campaigns appear lower.

4.2.3 Data Errors. One potential source of measurement error in our data is that incidents are reported with varying time lags from when they occurred. Data censoring might confound our measures of problem solving if reports filed sooner after an incident recorded fewer problem solving actions due to too little elapsed time to enable the reporter to record all relevant actions. To assess the validity of this concern, we compared the number of reported problem solving actions for incidents reported more quickly versus those reported more slowly, splitting the sample at the median (50th percentile) reporting

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[10] The incident reporting system includes fifteen incident types, but we exclude two, those related to adverse drug events or medication/intravenous issues, because the hospital tracks the resolution of these types of incidents with supplementary databases to which we did not have access.

lag in our data (one day). A t-test yielded no evidence that incidents reported more quickly had fewer reported actions, allaying this potential concern.[11]

4.3. Extensions

4.3.1 The Likelihood of Management-reported Problem Solving. Although the primary focus of our analysis is on frontline problem solving (reported by frontline workers), our dataset also enabled us to explore factors associated with management-reported problem solving. The role of managers in problem solving differs from that of frontline workers, and has been an important topic of study (Weiner, Shortell, and Alexander 1997). For example, Lee (1993) found that managers learn about operational failures not by direct observation but by receiving second-hand reports, typically transmitted after frontline workers have taken immediate actions. Another difference is that managers possess capabilities for problem solving that frontline workers lack including the ability to authorize resources (Shortell et al. 1995) and span unit boundaries and shifts (Tushman and Scanlon 1981). Thus, actions taken by managers to resolve operational failures often differ from those taken by frontline workers.

We created a variable to capture problem solving activities reported by managers based on the incident reporting system's "action" field, which was accessible only to managers. Actions reported in this field capture activities conducted at a broader, institutional level. We created ***any management-reported problem solving*** as a dichotomous variable coded "1" for incidents in which at least one action was taken by a manager in response to the incident, and "0" otherwise. For the same subset of incidents in the primary results reported above, 16% resulted in at least one manager-reported action. The results of our logistic regression model predicting *any management-reported problem solving* are presented in Column 1 of Table 5. Management problem solving was significantly more likely to occur when incidents posed financial risk (OR=17.3; $p<0.01$) or involved a patient (OR=1.3; $p<0.10$) or equipment (OR=2.2; $p<0.01$). Management problem solving was significantly *less* likely to occur for incidents associated with obstetrics risk (OR=0.072; $p<0.01$), which might be due to unit managers escalating these incidents for

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[11] Splitting the sample at the 75th percentile of the reporting lag in our sample (2 days) and 90th percentile (5 days) yielded identical results.

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follow-up by the those in the hospital's risk management department, whose actions are not captured in our dataset. Although we find no evidence that awareness campaigns affected the likelihood of managers investing effort in problem solving (OR=1.04; p=0.82), it is important to consider the broader context to avoid misinterpreting this result. A t-test across the broader set of thirteen incident types indicated that significantly more incidents were reported during or shortly after campaigns (14.4 versus 13.3 incidents per day across all incident types; p<0.05). Thus, whereas our regression results indicate that the *proportion* of incidents to which managers responded was indistinguishable between campaign and non-campaign periods,[12] applying this proportion to a greater number of reported incidents means that managers responded to a higher *number* of incidents per day during campaigns, 2.6 incidents per day during campaigns versus 2.3 during other periods across all incident types, a statistically significant difference (p<0.10 according to a t-test that compared these daily counts).

4.3.2 The Scope of Management-reported Problem Solving. We also explored the circumstances under which management actions were more likely to improve future operational performance. Managers' actions were considered "narrow problem solving" if they targeted a single incident, patient, or frontline worker, and therefore less likely to prevent similar incidents in the future. Examples include "care plan modified" and "feedback given to reporter." Managers' actions classified as "potential for broad problem solving," such as "environment modified" and "policy/procedure instituted," targeted multiple incidents, patients, or frontline workers, and were more likely to eliminate the root cause of the incident. Managers' actions were coded by the authors independently and discrepancies jointly resolved. Incidents were coded at the highest level of manager action. Accordingly, we created *scope of management-reported problem solving* as a categorical variable coded "no problem solving" for incidents with no associated manager actions (84% of incidents), "narrow problem solving" for incidents

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[12] A t-test indicated that managers responded to an average of 17.5% incidents per day during awareness campaigns versus 17.1% during other times of the year, a difference that was not statistically significant (p=0.69).

with only narrow associated manager actions (2%), and "potential for broad problem solving" for incidents with at least one such associated manager action (14%).[13]

We estimated a model that predicts this categorical variable using multinomial logistic regression. Results are presented in Columns 2a and 2b of Table 5 as relative risk ratios (RRR), the baseline category being "no actions." Wald tests assessed whether the independent variables had a significant impact on the choice between "shallow problem solving" and "deep problem solving" by testing whether the coefficients on these categories were equal. We focus our interpretation of the results on two interesting findings in which the independent variables have significantly different effects on the likelihood of shallow versus deep problem solving. For incidents that posed financial risk, deep management problem solving was significantly more likely than shallow management problem solving (i.e., the relative risk ratios differed significantly; χ^2=14.68; p<0.01). This large difference might reflect managers' greater discretion in allocating time and effort between profitable and not profitable services as wall as the likelihood that other resources might flow in greater abundance to more profitable services. Managerial awareness campaigns seemed to *deter* shallow management problem solving (RRR=0.32; p<0.01), a result we found surprising. In contrast, we found no evidence that these campaigns influenced the likelihood of deep problem solving relative to no problem solving. It is possible that the higher volume of incidents reported during campaigns required managers to engage in a form of triage that led them to prioritize opportunities to take deeper actions to address multiple incidents.

5. Discussion

Addressing and preventing operational failures has the potential to improve organizational performance (Tucker 2004). Incident reporting systems are designed to facilitate process improvement by systematically capturing operational failures. But little is known about the extent to which organizations use incident reports for problem solving, which incidents trigger frontline problem solving, and whether

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[13] We were unable to classify into our typology 27% of manager actions (10 of 37) such as loss of reputation and cost incurred. As a result, when an incident had one or more manager actions none of which we could classify, we coded *depth of management-reported problem solving* as missing. This resulted in 17 incidents for which we were unable to classify problem solving actions as shallow or deep.

managers can promote more problem solving among frontline personnel. We examined the latter two questions in the health care context, in which operational failures are common and potentially catastrophic and solving problems to improve processes is one of the industry's highest priorities.

Our research demonstrates that both incident characteristics and managerial behavior affect problem solving behavior among frontline workers. With respect to incident characteristics, we hypothesized that workers would engage in more problem solving when operational failures risked financial harm or legal liability. We found evidence that incidents associated with liability concerns prompted more problem solving actions. This finding is consistent with MacDuffie's (1997) observation that Honda expected its frontline autoworkers to prioritize their problem solving efforts towards problems more likely to trigger customer concerns. Whereas dissatisfaction with quality in the automotive context is often registered via complaints, dissatisfaction in hospitals is often expressed by filing lawsuits. In both cases, deterring the threat of these complaints is associated with greater frontline problem solving. Future research is required to determine the extent to which the threat of customer dissatisfaction drives frontline problem solving in other contexts.

Financial risk spurred problem solving among managers, but not frontline workers. There are several potential explanations for this finding. First, managers might be more sensitive than frontline workers to the financial implications of serving profitable patients. Alternatively, it is possible that frontline workers do respond to financial risk, but do so by undertaking qualitatively different types of problem solving, rather than more problem solving. For example, staff members might spend more time instructing a patient by demonstrating rather than quickly explaining a behavior. We were unable to evaluate such potential differences in the time and resources devoted to each action.

We also hypothesized that management commitment to problem solving would encourage problem solving among frontline workers. We focused on two manifestations of management commitment: managerial communication through awareness campaigns, and managerial engagement through modeling of problem solving behavior. We found frontline workers in units in which managers engaged in more problem solving to be more likely to conduct problem solving in response to reported

incidents. Our finding that managers serving as role models can affect workers' discretionary efforts to improve processes is consistent with findings of a previous study that workers whose managers emphasized safety by discussing it more often with their subordinates engaged in safer work practices (Zohar 2002a).

We also found frontline workers whose managers promoted frontline problem solving via an awareness campaign to be more likely to conduct problem solving in response to reported incidents. Our empirical context did not, however, enable us to determine the duration that maximizes the effectiveness of awareness campaigns. If novelty drives salience and, therefore, action, effectiveness might diminish if campaigns are run for extended periods or repeated frequently. Further research is required to understand how campaign length or frequency affects salience as well as the conditions under which campaigns occasion temporary versus enduring increases in frontline problem solving. Although awareness campaigns promoted frontline problem solving, they did not affect the number of problem solving actions taken. This finding might stem from exacerbation of underreporting of actions in the incident reporting system during campaigns, making the number of actions taken in response to incidents during campaigns appear lower. But it might also reflect the challenge of thoroughly resolving operational failures when a higher volume of problems is exposed. This interpretation sounds a cautionary note in that sporadic awareness campaigns do not ensure capacity for adequate action. Superficial response can contribute to what Bohn (2000) has described as a "firefighing climate." An emphasis on problem solving without a commensurate increase in resources to help frontline workers take action to resolve problems thoroughly could thwart their efforts, despite a desire to respond to managers' appeals. Absent sufficient capacity to address problems, awareness campaigns could frustrate workers and add to skepticism about management's commitment to problem solving.

Our findings also suggest that managerial communication and engagement, the two forms of management commitment studied, appear to substitute for rather than complement one another. Specifically, managerial awareness campaigns provoke more problem solving among frontline workers whose managers routinely engage in lower levels of problem solving. This result might be heartening to

managers unable to devote the time they would like to demonstrate their commitment through the modeling of problem solving behavior. Understanding why awareness campaigns do not increase frontline worker problem solving in units with higher levels of managerial engagement is an area for future research. Perhaps the higher volume of incident reports filed during awareness campaigns makes it difficult for highly engaged managers to devote more time to resolving incidents, and thereby deters frontline workers in these areas from engaging in more problem solving.

Despite recognition that studying operational failures has the potential to promote operational improvement, prior research has not considered the types of reported incidents that trigger problem solving. Our study provides the first evidence that certain types of incidents systematically promote more problem solving than others. Whereas prior research indicates that a learning orientation leads to fewer problems (Stern, Katz-Navon, and Naveh 2008), our results show that incident characteristics and management commitment might also influence the occurrence of learning.

5.1 Contributions to Theory and Practice. In addition to contributing to the literature on incident reporting, our study extends the literature on the benefits of problem solving for process improvement. Our research focused on when problem solving occurs and how managers can promote it. Research about the Toyota Production System has described organizations the practices of which support rapid and nearly universal response to operational failures (Spear and Bowen 1999). But the problem solving literature says little about when workers engage in problem solving in organizations that do not adhere to such strict standards.

Tucker and Edmondson (2003) distinguished two types of problem solving based on whether frontline workers simply worked around the immediate problem (first order problem solving) or also attempted to resolve the problem by calling attention to it (second order problem solving). They found that frontline workers engaged in second order problem solving for just 7% of problems. While focusing exclusively on second order problem solving (as all incident reports call attention to problems), our findings reveal particular characteristics of incidents and the contexts in which they occur that are associated with more frontline problem solving. In doing so, our results promote a better understanding of

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frontline workers' potential to improve processes and mitigate operational failures. By identifying particular features and contexts of incidents that are less likely to spur problem solving, our results also highlight a heightened need for other approaches to address incidents less likely to pose liability or financial risks.

Our study also provides a better understanding of the ways frontline workers address operational failures. Tucker and Edmondson (2003) investigated problem solving following two types of failures: problems and errors, which they distinguished based on the underlying cause of the failure. We focused on a different categorization of failures based on their consequences. Together, these papers begin to build a comprehensive understanding of the characteristics of operational failures that promote problem solving. We introduce an important distinction within Tucker and Edmondson's (2003) category of second order problem solving based on the scope of problem solving. Specifically, our database contained instances of narrow and broad problem solving, the latter affording greater opportunity for operational performance improvement. We also found both types of problem solving to occur at different levels within the organization, that is, among frontline workers and managers. Additional research to more fully develop a typology of problem solving at all organizational levels would be beneficial.

Our study also contributes to the problem solving literature by focusing on the role managers can play in promoting problem solving. Our findings suggest that managerial awareness campaigns can interrupt periods of inertia and create windows of opportunity for problem solving related to operational failures, a pattern others have identified in the problem solving that accompanies adoption of new technologies (Gersick 1988; Tyre and Orlikowski 1994). We found awareness campaigns to be particularly effective at spurring problem solving in organizational units characterized by low managerial engagement in problem solving. This introduces an important contingency regarding the circumstances under which such "windows of opportunity" (Tyre and Orlikowski 1994) and "punctuated equilibriums" (Gersick 1988) might be particularly likely to emerge. It also suggests that these two forms of managerial commitment serve primarily as substitutes and not complements. Thus, whereas managerial consistency might be important (Kopelman et al. 1990, Rogg et al. 2001), its benefits might be limited in situations in

which the potential for extra effort is limited. Alternatively, this discrepancy might be explained by a distinction among levels of management. In our context, managerial communication and managerial engagement were enacted by different types of managers (senior managers and line managers, respectively). It might be that managerial consistency matters within a given level of management or for a given manager, but different forms of commitment work as substitutes across levels. Additional exploration is needed to flesh out such distinctions.

Finally, our study has implications for the extensive literature that examines and seeks to identify ways to mitigate the substantial underreporting of incidents in the presence of incident reporting systems. For example, according to Vincent (2006: 61), incident reporting systems can be an effective tool for mitigating problems only if those responsible for reporting incidents "see it is worthwhile . . . [and] if not then there are always reasons why this or that incident does not need to be reported." By highlighting a positive association between the extent to which frontline staff and their managers engage in problem solving activities, our results highlight the possibility that greater levels of managerial engagement in problem solving might spur frontline workers to report a greater proportion of incidents as well as near misses.

Our study also provides insights for managers. Our results reveal characteristics of incidents that are particularly likely to prompt frontline workers to engage in problem solving. Managers now can assess the extent to which frontline workers' prioritization of these types of incidents aligns with organizational objectives and develop strategies to encourage problem solving among types of incidents for which problem solving is less than optimal. Our findings also highlight two strategies managers can employ to influence problem solving behavior among frontline workers, specifically, demonstrating, through words and actions, their commitment to problem solving. Managers could signal, for example, the appropriateness of learning from near misses by engaging in problem solving following near misses as if they were reportable incidents or by calling for such a response in an awareness campaign.

5.2 Limitations and Future Research. This study has several limitations. Our hospital has made a substantial effort to promote patient safety via an array of approaches. Although this raises some

concern about generalizability, findings in this setting define what can be expected in hospitals that dedicate resources to improving patient safety via incident reporting, and identify areas in which hospitals with mature patient safety programs can improve the use of existing incident reporting systems.

We determined, as reported above, that the rate of incident reporting at this hospital is similar to statewide rates. Further, academic medical centers, being highly complex institutions, are often compared to industries such as aviation that also require highly reliable results (Gaba 2000). We also had to consider the unique structure of the health care industry, which forced us to define profitable services based on decisions made by customers' doctors. This could impair generalizability, given that in most industries customers themselves make decisions about where to conduct business. Similarly, one of our measures of legal liability captured patients' involvement in incidents. In an industry in which frontline workers are trained first and foremost to "do no harm," incidents involving patients evoke not only liability risk but an emotional response that might prompt problem solving, which we could not disentangle, but provides an opportunity for future research. Future work could also examine how various risks associated with incidents affect frontline problem solving in other industries in which customers make direct decisions (e.g., airlines) and emotional stakes are lower.

Many scholars have described how organizational culture affects incident reporting (Waring 2005; Cooke, Dunscombe, and Lee 2007), dedication to quality improvement (Carman et al. 1996), and safety outcomes (McFadden, Henagan and Gowen 2009; Singer et al. 2009). Our empirical context was confined to a single hospital, which enabled us to control for hospital-level culture. Prior research, however, has revealed that work groups within hospitals can exhibit significantly different cultures that influence the propensity for individuals to report incidents (Edmondson 2004; Naveh, Katz-Navon, and Stern 2006) and likelihood of successfully implementing process improvements (Tucker, Nembhard, and Edmondson 2007). Confidentiality restrictions that accompanied our data access prevented us from examining intra-organizational differences in culture that might affect incident reporting and problem solving. Future research could examine how organizational culture affects problem solving in response to

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reported incidents across several organizations as well as within different departments within the same organization.

We also advocate for linking our focus on the determinants of problem solving to the phenomenon of underreporting, which has been examined in much prior research on incident reporting. Indeed, among many causes of underreporting is concern about the futility of reporting owing to a perception that little if any problem solving would actually follow a reported incident (Ghandi et al. 2005). Similarly, frontline workers have stated that more evidence linking incident reports to system changes would increase the likelihood of reporting incidents (Taylor et al. 2004; Evans et al. 2006). Studies could test whether more visible problem solving following incidents does, in fact, lead to more incident reporting, perhaps focusing on the types of incidents managers are most concerned are underreported.

6. Conclusion

This study is the first quantitative analysis of which reported operational failures are more likely to promote problem solving. Our findings provide evidence that supports the theory that problem solving in response to operational failures is influenced by both the risk posed by the incident and the extent to which management demonstrates a commitment to problem solving. By explaining some of the variation in responsiveness, this study empowers managers to adjust their approach to problem solving. Although we explored the characteristics of operational failures associated with problem solving, the present study did not determine whether organizations actually learn from the incidents to which they respond, and did not assess the effectiveness of responses. Future research should assess the extent to which incident reporting systems occasion reductions in operational failures.

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Table 1. Incident Types

Incident type	Definition	Percent of incidents of this type
Blood/Blood Product	Incident related to the prescribing, processing, dispensing, or administration of blood or blood products.	46%
ID/Documentation/Consent	Incident related to identification, chart documentation of consent, etc. that is not a contributing factor to another incident type.	11%
Lab Specimen/Test	Incident related to ordering, preparation, performance, or results of a lab specimen/test.	28%
Surgery/Procedure	Incident related to ordering, preparation, or performance of a surgical procedure or anesthesia.	14%
		Total = 7,407

Note: Incident type definitions were provided by the hospital.

Table 2. Summary Statistics

Variable	Mean	SD	Min	Max
Any staff-reported problem solving	0.24	0.43	0	1
Number of staff-reported problem solving actions	0.33	0.76	0	8
Any management-reported problem solving	0.16	0.36	0	1
Profitable service	0.11	0.32	0	1
Legal liability concern – patient present	0.89	0.31	0	1
Legal liability concern – obstetrics	0.10	0.30	0	1
Awareness campaign	0.22	0.41	0	1
Managerial engagement	0.21	0.26	0	1
Patient or clinical area	0.11	0.31	0	1
Temporary patient harm	0.03	0.17	0	1
Permanent patient harm	0.00	0.05	0	1
Patient death	0.00	0.03	0	1
Equipment involved	0.04	0.20	0	1
Profitability of unit in which incident occurred not known	0.71	0.45	0	1
Manager engagement of unit in which incident occurred not known	0.02	0.12	0	1
Area in which incident occurred not specified in the incident report	0.87	0.34	0	1

N = 7,407 incidents

Table 3. Correlations

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Any staff-reported problem solving	1.00												
2	Number of staff-reported problem solving actions	0.76	1.00											
3	Any management-reported problem solving	-0.06	-0.04	1.00										
4	Profitable service	-0.01	-0.02	0.15	1.00									
5	Legal liability concern – patient present	0.08	0.06	0.07	0.05	1.00								
6	Legal liability concern - obstetrics	0.11	0.08	-0.13	0.04	0.03	1.00							
7	Awareness campaign	0.01	0.00	0.02	-0.02	-0.01	-0.01	1.00						
8	Managerial engagement	-0.08	-0.06	0.46	0.34	0.11	-0.17	-0.02	1.00					
9	Patient or clinical area	0.12	0.30	-0.05	-0.06	-0.02	-0.04	0.01	-0.10	1.00				
10	Temporary patient harm	0.00	0.07	0.00	0.00	0.06	-0.01	0.00	-0.03	0.16	1.00			
11	Permanent patient harm	0.00	0.02	0.00	-0.01	0.02	0.00	0.00	-0.01	0.05	-0.01	1.00		
12	Patient death	0.01	0.02	-0.01	-0.01	0.01	-0.01	-0.01	0.00	0.04	0.00	0.00	1.00	
13	Equipment involved	-0.01	0.07	-0.04	-0.05	-0.17	-0.05	0.00	-0.08	0.26	0.09	0.02	-0.01	1.00

N=7,407 incidents

Table 4.
Staff-Reported Problem Solving:
Logistic and Negative Binomial Regression Results

Dependent variable	(1a) (1b) Any staff-reported problem solving actions		(2a) (2b) Number of staff-reported problem solving actions	
	Logit		Negative binomial	
	Odds ratios		Incidence-rate ratios	
H1 Financial risk	0.707**	0.702**	0.859*	0.854*
	[0.106]	[0.105]	[0.079]	[0.078]
H2 Legal liability risk – patient present	3.528***	3.544***	1.907***	1.908***
	[0.497]	[0.500]	[0.224]	[0.224]
H2 Legal liability risk – obstetrics	1.453***	1.458***	1.363***	1.365***
	[0.168]	[0.168]	[0.100]	[0.100]
H3 Awareness campaign	1.541**	1.710***	1.056	1.151
	[0.272]	[0.320]	[0.143]	[0.163]
H4 Managerial engagement	1.761***		1.556***	
	[0.289]		[0.173]	
H5a Managerial engagement during awareness campaign		1.067		0.994
		[0.378]		[0.235]
H5b Managerial engagement not during awareness campaign		2.015***		1.745***
		[0.351]		[0.210]
Patient or clinical area	1.646	1.653	1.317	1.329
	[0.591]	[0.593]	[0.275]	[0.276]
Temporary patient harm	1.369	1.367	1.645***	1.641***
	[0.346]	[0.345]	[0.281]	[0.280]
Permanent patient harm	1.615	1.648	1.211	1.229
	[1.271]	[1.297]	[0.689]	[0.696]
Patient death	1.076	1.065	0.594	0.585
	[0.751]	[0.752]	[0.197]	[0.200]
Equipment involved	0.907	0.91	1.044	1.046
	[0.248]	[0.248]	[0.180]	[0.180]
Incident type fixed effects	Included	Included	Included	Included
Month fixed effects	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included
Observations	7,407	7,407	7,407	7,407
Log likelihood	-2,138	-2,136	-4,279	-4,277
Model Wald Chi-squared	1,136***	1,141***	1,498***	1,516***
McFadden's R-squared	0.48	0.48	0.22	0.22
Mean dependent variable in this sample	0.24	0.24	0.33	0.33
Predicted probability at mean of all variables	0.24	0.24	0.35	0.35

Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.10. All models include a dummy variable (*managerial engagement undetermined*) designating incidents that took place in units with no reported incidents in the prior year, a dummy variable (*profitability undetermined*) to indicate incidents for which the profitability of the unit in which the incident occurred could not be determined, and a dummy variable designating that the area in which the incident occurred was not reported. Likelihood ratio tests indicated that addition of the interaction term significantly improved the model fit for Model 2b compared to Model 2a (χ^2= 4.90; p<0.05) and marginally improved the model fit for Model 1b compared to Model 1a (χ^2= 2.52; p<0.11).

Table 5.
Management-Reported Problem Solving:
Logistic and Multinomial Logistic Regression Results

Dependent variable	(1) Any management-reported problem solving actions	(2a)	(2b)	(2c)
		Scope of management-reported problem solving		
	Logit	Multinomial logit		
	Odds ratios	Relative risk ratios		Wald test of equality of coefficients (χ^2 values)
Category		Shallow problem solving	Any deep problem solving	
Financial risk	17.284***	3.649***	23.656***	14.68***
	[3.454]	[1.599]	[5.413]	
Legal liability risk – patient present	1.287*	1.404	1.310*	0.04
	[0.186]	[0.471]	[0.213]	
Legal liability risk – obstetrics	0.072***	0.063***	0.073***	0.02
	[0.024]	[0.062]	[0.026]	
Awareness campaign	1.037	0.321***	1.306	9.75***
	[0.159]	[0.138]	[0.217]	
Patient or clinical area	1.141	3.076*	0.867	3.26*
	[0.320]	[2.009]	[0.275]	
Temporary patient harm	1.143	1.561	0.858	1.85
	[0.239]	[0.621]	[0.211]	
Permanent patient harm	2.923	0.000***	0.972	652.40***
	[2.751]	[0.000]	[1.232]	
Patient death		0.000***	0.000***	2.78*
		[0.000]	[0.000]	
Equipment involved	2.192***	1.718	2.768***	0.57
	[0.560]	[0.975]	[0.825]	
Incident type fixed effects	Included	Included		
Month fixed effects	Included	Included		
Year fixed effects	Included	Included		
Observations	7,402	7,385†		
Log likelihood	-2,767	-3,089		
Model Wald Chi-squared	527***	8,170***		
McFadden's R-squared	0.14	0.15		
Mean dependent variable in this sample	0.16			

In Columns 2a and 2b, the relative risk ratios are relative to "no actions," the baseline category. Column 2c reports the chi-squared statistic of a Wald test of the equality of coefficients from Columns 2a and 2b; a statistically significant result indicates that the coefficients differ. Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.10. Both models also include a dummy variable (*profitability undetermined*) to indicate incidents for which the profitability of the unit in which the incident occurred could not be determined, and a dummy variable designating that the area in which the incident occurred was not reported.

† The slightly smaller sample in Model 2 is due to our excluding 17 incidents for which we were unable to classify problem solving actions as shallow or deep.

**Figure 1.   Predicted Probability of Staff-Reported Problem Solving
by Level of Managerial Engagement and Awareness Campaign**
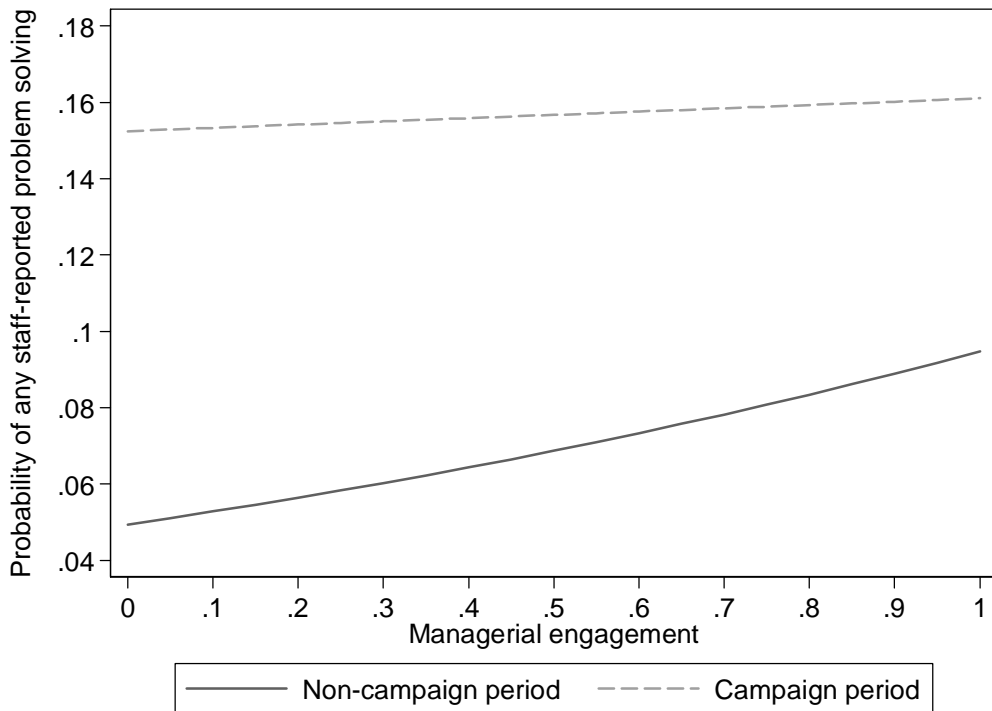
This graph depicts the predicted probability of any staff-reported problem solving at various levels of managerial engagement (from 0% to 100% plotted in increments of 5%) during campaign periods (solid line) and outside of campaign periods (dashed line), when all other variables were held at their means.